PATENT SPECIFICATION

(11) 1 466 022

(21) Application No. 2969/75 (22) Filed 23 Jan. 1975
(31) Convention Application No. 2 403 007
(32) Filed 23 Jan. 1974
(31) Convention Application Nos. 2 500 537 and 2 500 480
(32) Filed 8 Jan. 1975 in
(33) Fed. Rep. of Germany (DT)
(44) Complete Specification published 2 March 1977
(51) INT CL² G05D 16/04
(52) Index at acceptance
G3P 1C 24K5 3 9A3 9A4 9A6 X
F2V D6A2 E1C5 E2B2 E5C

(19)

1 466 022

(54) PILOT-CONTROLLED PRESSURE RELIEF VALVES

(71) We, ZAHNRADFABRIK FRIEDRICHSHAFEN AKTIENGESELLSCHAFT, of Friedrichshafen-on-the-Bodensee, Federal Republic of Germany, a Joint-Stock Company organised under the laws of the Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a relief valve comprising a housing, an inlet and an outlet in said housing which are separated by a spring-loaded piston-like valve controlled by a pilot valve.

Pilot-controlled pressure relief valves of known construction generally have a piston valve loaded by a spring accommodated in a spring chamber and a pilot valve loaded by a further spring. Such a relief valve is arranged as a flow regulating valve in a pump, for example, in German Published Specification 1,553,290. In this valve there are also required two springs for the piston valve and the pilot valve. Because of a control channel located in the housing which carries the pressure medium from the inlet of the valve into the spring chamber at the back of the piston valve, there is an additional requirement for a comparatively large amount of space for the fitting of such relief valves. For fitting in pumps and other hydraulic units, however, generally there is only a strictly limited amount of space.

The problem which the invention aims at solving is therefore to provide a pilot controlled relief valve which does not require a large amount of space and is suitable without great expenditure for hydraulic pumps and hydraulic installations having only a small amount of space for fitting.

Accordingly, the present invention consists in a relief valve comprising a housing, an inlet and an outlet in said housing which are separated by a spring-loaded piston-like valve controlled by a pilot valve which is operated by differential pressure, the pilot valve having two opposed surfaces subjected to inlet pressure, one surface being larger than the other, and a surface located axially intermediate the opposed surfaces and subjected to outlet pressure.

In order that the invention may be more readily understood, reference is made to the accompanying drawings which illustrate diagrammatically and by way of example several embodiments thereof, and in which:—

Fig. 1 shows a longitudinal section through a relief valve according to the invention in an arrangement showing the principle of operation, and

Figs. 2 to 11 show further embodiments of the relief valve.

In the drawings and in the description elements of the individual embodiments which correspond to one another are provided with the number of initial digits corresponding to the Figure.

A piston valve 1 is arranged so that it can be moved axially in a housing 2. The housing 2 has an inlet 4 leading to one end face 3 of the piston valve 1, and an outlet 5. A compression spring 6 is arranged in a spring chamber 7 formed at the other end face of the valve 1. In the piston valve 1 there is arranged a pilot valve 8 in the form of a stepped piston 9 loaded by the compression spring 6.

A throttle bore 10 located in the stepped piston 9 connects the inlet 4 with the spring chamber 7, so that on the two equal-sized end surfaces of the piston valve 1 and on the two end surfaces of different size of the stepped piston 9 the same pressure obtains. A differential surface 11 located axially between the two end surfaces of the stepped piston 9 is connected via a radial bore 12 in the piston valve 1 with the outlet 5.

In the closed position of the valve represented in Fig. 1 the stepped piston 9 and also

AJ

the piston valve 1 are held by the compression spring 6 in their positions as shown. If the pressure in the inlet 4 exceeds a given value resulting from the magnitude of the force of the compression spring 6 and the magnitude of the differential area 11 and the pressure in the outlet 5 acting on it, the stepped piston 9 is moved out of its position as shown towards the right until the spring chamber 7 is connected with the outlet 5, via a control edge 13 on the stepped piston 9, and with the radial bore 12. The pressure in the spring chamber 7 decreases so that the pressure on the end face 3 of the piston valve 1 predominates and the piston valve 1 is also moved towards the right against the force of the compression spring 6. In this way a direct connection is produced from the inlet 4 to the outlet 5.

A further embodiment of this arrangement of basic principle is represented in Fig. 2. The stepped piston 9 of Fig. 1 is replaced by a simpler piston 14 with a pin-like projection 15 and by a ball 16 having a valve seat 17 in the piston valve 201. These parts are easier to produce and offer a better sealing action.

The action of the pilot valve 208 is achieved in that the cross-sectional area of the piston 14 is designed greater than the cross-sectional area of the valve seat 17. The cross-sectional area of the piston 14 thus corresponds to the greater cross-sectional area of the stepped piston 9, whilst the cross-sectional area of the valve seat 17 corresponds to the smaller cross-sectional area of the stepped piston 9. The ball 16 is urged via a spring plate 18 by the compression spring 206 against the valve seat 17 on the piston valve 201. A throttle bore 210 connects the inlet 4 with the spring chamber 207.

By virtue of such construction and the small amount of pressure medium which passes through the valve seat 17, only a very small travel of the ball 16 is required and therefore also of the piston 14 for the purpose of actuating the pilot valve 208. It is therefore possible to seal the piston 14 in the bore 19 of the piston valve 201 by means of a radially pre-stressed washer 20 made of high-viscosity plastics. This washer 20 is prevented by its radial pre-stressing from an axial displacement in the bore 19, so that the pressure in the inlet 4 is transmitted without frictional losses by the elasticity of the washer 20 onto the piston 14 of the pilot valve 208.

Generally speaking the washer 20 is sufficient to secure the piston 14 from falling out of the bore 19 of the piston valve 201. For cases in which a rise in the magnitude of pressure in the outlet 5 above the magnitude of the pressure in the inlet 4 is possible, the washer 20 is additionally secured by means of a supporting washer, for example rolled in, not shown in the drawing.

Sealing of the bore 19 by the washer 20 permits of a greater fitting tolerance between the bore 19 and the piston 14, so that this gives rise to a simplification during production.

Since as a result of the arrangement of the plastics washer 20 in the bore 19 there is no leakage flow past the piston 14, a jamming of the latter in the bore 19 is prevented. This means that the accuracy of response of the pilot valve 208 is increased. At the same time it is possible to dispense with the usual longitudinal pressure relief grooves in the periphery of the piston 14.

The entire relief valve is advantageously arranged in a screw-in cartridge 21. This screw-in cartridge 21 can be screwed into various units without any accurate machining of the drillings in the housing being necessary. This also provides for an easy interchangeability of the valve.

As has already been described above, the pilot valve 208 only has a very small stream of pressure medium flowing through it, which only calls for a very small strpoke on the part of the ball 16 and consequently a very small opening gap between the ball 16 and the valve seat 17. As a result of its smallness, the gap acts like a very fine plate filter which filters out any fine particles of dirt contained in the pressure medium. These particles of dirt can settle out on the sealing edge of the valve seat 17 and lead to a leakage of the pilot valve and to a consequent insufficient pressure of closure of the piston valve 201.

Another advantageous embodiment of the relief valve is shown in Fig. 3. Between the inlet 4 and the throttle bore 310 a filter 22 is arranged, which is surrounded by a piece of tubing 23. In order to achieve a good filter effect, a narrow-mesh filter material is used. A pressure gradient brought about by this is of no importance, because only a small stream of pressure medium flows through the throttle bore 310. Such a filter can also be used in the other embodiments.

Different from the embodiment according to Fig. 2, in the case of the pilot valve 308, the ball 16 is replaced by a cone valve 24. The cone 24 shows a lesser tendency to oscillate than a ball. A pin-shaped projection 315 is connected with the cone 24. It is therefore possible to use a bulk-produced bearing needle for the piston 314.

A further embodiment is shown in Fig. 4. The valve seat 417 of the cone valve 424 is formed by a ring 25 which can be inserted in the piston valve 401. This ring 25 limits the smaller cross-sectional area of the pilot valve in a radial direction. As a result of the two-part construction of the valve seat 417 in the piston valve 401, a very accurate

production of the valve seat is possible.

In the embodiment according to Fig. 5, the larger cross-sectional area of the pilot valve is formed by a conical lift valve 524 and the smaller cross-sectional area is formed by a piston 514. The piston 514 is mounted in a ring 46 arranged in the piston valve 501. The throttle bore 510 is arranged upstream of the pilot valve 508. A bore 26 connects the two ends of the pilot valve 508 with one another, so that the same pressure obtains upstream and downstream of the pilot valve 508. In this embodiment the valve 524 has the flow passing through it. In this way in the event of wear of the valve seat 517 and the consequent enlarging of the effective cross-sectional area, a greater reliability is ensured.

Fig. 6 shows an embodiment which is simplified as compared with that of Fig. 5. In this case the single-part stepped piston with the conical lift valve 524 and the piston 514 is replaced by a lift valve 624 in the form of a ball and a piston 614 in the form of a roller bearing needle. The piston 614 is mounted in a ring 646. The throttle bore 610 is arranged in a throttle cap 27 upstream of the pilot valve 608 and attached to the piston valve 601.

The bore 626 serves as an equalisation bore for the piston valve 601.

In the spring chamber 607 there is arranged a connection 28 for a remote control device which is not shown in the drawing. Remote control of the relief valve, which can be used in all the embodiments of the valve shown, is achieved in that the spring chamber 607 is connected via the remote control device, for example a simple switch valve, with a pressure medium reservoir not shown in the drawing.

The pilot valve 708 of Fig. 7 uses two pistons 714*a* and 714*b* of different diameters. The throttle bore 710 is arranged in a throttle cap 727 upstream of the pilot valve 708.

In Fig. 8 the pilot valve 808 is arranged in a screw-in cartridge 821. Such an arrangement of the pilot valve is possible in principle also with the other embodiments shown.

When the pilot valve is mounted in a bore of the relief valve and the latter is of small constructional dimensions, the machining of this bore presents difficulties which can be obviated by the construction of Fig. 9.

Fig. 9 shows a relief valve 901 and pilot valve assembly 908 carried in a cartridge 921, threaded as in the other embodiments in a housing 902. Also, as in the other embodiments, the relief valve is seated against a stop limit ring at its upstream surface 903, the ring being carried in the upstream end of the cartridge and the surface 903 being exposed to pressure in the inlet 904. The relief valve is biased to closing position as by the compression spring 906 so that upon opening of pilot valve 908, pressure fluid will flow to outlet 905 from the chamber 907 maintained under inlet pressure through throttle bore 910 and relief valve 901 can then open.

In this instance, a stationary ball 929 is seated against a movable valve opening 917 effected by the swaged over lip 936 defining a coaxial opening in a spring retainer collar or tubular movable valve member 928 cooperating with a ring 933 which is slidable on a support collar 930 and provided with an O-ring seal 934 on that collar. Collar 930 connects the interior of the valve member 928 with pressure in the outlet 905. Ring 933 abuts a shoulder S on the valve member 928. The spring 906 has a reaction at the upstream end against the end wall of the relief valve 901 and at the downstream end against a radial end flange 937 of valve member 928. The collar 930 is a tubular extension coaxial of and integral with the cartridge, and having integrally at its free end, spaced protruding fingers F, as shown, abutting the ball 929 for axial support.

An annular space 932 is effected between the valve member 928, and collar 930, at the end of the collar 930. The outlet 905 has constant communication via passage 931 to space 932.

From the above description it will be noted that with the closure of ball 929 against opening 917, as shown, effected by spring bias on flange 937, inlet pressure in chamber 907 acts to maintain closure on the exterior radial area of lip 936. The pressure force biases the valve member 928 to the right to maintain the pilot valve closed. Thus, the effective closing pressure acting on member 928 is on the overall cross-sectional area indicated by double headed arrow 935 less the overall flow area through valve opening 917, indicated by double headed arrow 938. This is the smaller area of the differential surface area subject to inlet pressure.

Inlet pressure also acts to move the valve member 928 to the left away from ball 929 to open the pilot valve upon predetermined rise of pressure in chamber 907. The effective opening pressure acting to move member 928 to the left is substantially on the exterior radial area of seal 934 and flange 937. This amounts to the overall cross-sectional area indicated by the double headed arrow 935 less the overall cross-sectional area of collar 930 indicated by double headed arrow 939 and is the larger area of the differential area surfaces. The annular surface of ring 933 adjacent the space 932 constitutes the axially intermediate surface subjected to outlet pressure.

The differential effective area arrangement is predetermined to provide a net closure bias i.e. including the spring bias, which can be overcome by predetermined inlet pressure to open the pilot valve 908 and thus drop the pressure in chamber 907. Relief valve 901 can then overcome the spring bias to connect the inlet 904 to the outlet 905. As in all the abovementioned modifications, the relief valve is balanced hydraulically and maintained closed by spring bias. The particular modification uses components which are relatively simple to manufacture and the valve member 928, spring loaded, renders a stable balance and good sealing.

The embodiments shown in Figs. 10 and 11 differ essentially from the previous embodiments in that a conical head valve is used in the relief valve instead of a piston valve. This provides a more certain seal for the relief valve.

Referring particularly to Fig. 10, a pressure operated relief valve 1001 is disclosed axially slidable within sleeve portion 1041 integral with threaded cartridge portion 1021 within the housing 1002. The relief valve is biased closed as by compression spring 1006 so that sharp edge 1043 seals closely against the conical area 1040 of the valve seat 1042 at the upstream end of the cartridge as shown. Thus, the relief valve end wall 1003 closes inlet passage 1004 but opens that passage upon moving to the right for venting to outlet 1005. The end wall 1003 of the relief valve is provided with a restricted bore, as shown, for effecting inlet pressure in the chamber 1007. A ring seal 1044 is provided at the downstream end of the relief valve in sliding co-action with the interior wall 1045 of the cartridge sleeve portion. Thus, it will be apparent that the conical valve construction which comprises the cylindrical extension 1041 of the cartridge and the conical seat in conjunction with the conical valve head makes up a tightly sealing relief valve arrangement having equal upstream and downstream areas to effect a hydraulically balanced valve.

In this instance, the pilot valve assembly is the same as that described in Fig. 9, as is the operation thereof and therefore need not be repetitiously described.

In general, spring 1006 will maintain closure of the relief valve but where space limitations are such that a sufficiently large spring cannot be used, the embodiment of Fig. 10 is changed so as to provide pressure unbalance on the relief valve. Thus, in Fig. 11 a hydraulically unbalanced relief valve is fragmentarialy disclosed wherein the valve body 1101 has differential areas which are provided by a conical valve seat 1140 somewhat smaller than the diameter of the internal surface 1145. It will then be apparent that inlet pressure acting inside the chamber will have a total force to the left greater than inlet pressure to the right considering the effective areas upstream and downstream. Accordingly, the relief valve 1101 is pressure biased to closing position and a smaller spring may be utilized.

WHAT WE CLAIM IS:—

1. A relief valve comprising a housing, an inlet and an outlet in said housing which are separated by a spring-loaded piston-like valve controlled by a pilot valve which is operated by differential pressure, the pilot valve having two opposed surfaces subjected to inlet pressure, one surface being larger than the other, and a surface located axially intermediate the opposed surfaces and subjected to outlet pressure.

2. A relief valve as claimed in claim 1, wherein the larger surface of the pilot valve is connected directly with the inlet, whilst the smaller surface of the pilot valve is subjected to pressure within a chamber of the piston-like valve which accommodates a compression spring, said spring engaging by its one end the smaller surface of the pilot valve.

3. A relief valve as claimed in claim 2, wherein the larger surface of the pilot valve is connected with the inlet via a throttle bore in the piston-like valve, whilst the smaller surface of the pilot valve is subjected to pressure within the spring chamber.

4. A relief valve as claimed in any of the preceding claims, wherein the larger and the smaller surfaces of the pilot valve are each formed by a piston.

5. A relief valve as claimed in any of claims 1 to 3, wherein the larger surface of the pilot valve is formed by a piston and the smaller surface is formed by a lift valve.

6. A relief valve as claimed in any of claims 1 to 3, wherein the larger surface of the pilot valve is formed by a lift valve and the smaller surface is formed by a piston.

7. A relief valve as claimed in any of the preceding claims, wherein the smaller surface of the pilot valve is limited in a radial direction by a ring which is insertable in the piston-like valve.

8. A relief valve as claimed in any of claims 1 to 5 or 7, wherein the end portion of the pilot valve which has the larger surface is received in a bore of the piston-like valve which bore is closed by a plastics washer.

9. A relief valve as claimed in any of claims 3 to 8, wherein a filter is arranged between the inlet and the throttle bore of the piston-like valve.

10. A relief valve as claimed in any of the preceding claims, wherein the relief valve is

arranged in a cartridge screwable into the housing.

11. A relief valve as claimed in any of the preceding claims, wherein the pilot valve is arranged in the piston-like valve.

12. A relief valve as claimed in claim 10, wherein the pilot valve is arranged in said cartridge.

13. A relief valve as claimed in any of the preceding claims, wherein the spring chamber is connected with a connection bore for remote control.

14. A relief valve as claimed in claim 1, wherein the pilot valve comprises a tubular movable valve closure member supported on a cylindrical projection, the smaller surface of the pilot valve being formed by the difference between the area of an end surface of the closure member and the area of a circular surface bounded by the valve seat, whilst the larger surface of the pilot valve is formed by the difference between the area of said end surface and the area of a circular surface bounded by the outer circumference of the cylindrical projection.

15. A relief valve as claimed in claim 1, wherein the piston-like valve cooperates with a conical valve seat arranged between the inlet and the outlet, and cooperates with a cylindrical sealing surface by means of an elastic sealing ring mounted in the piston-like valve to provide a seal between the spring chamber located in the piston-like valve and the outlet.

16. A relief valve as claimed in claim 15, wherein the conical valve seat has a smaller diameter than the cylindrical sealing surface.

17. Relief valves, substantially as herein described with reference to and as shown in the accompanying drawings.

VENNER, SHIPLEY & CO.,
Chartered Patent Agents,
Rugby Chambers, 2, Rugby Street,
London, WC1N 3QU.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1977.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1466022 COMPLETE SPECIFICATION
10 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG.1

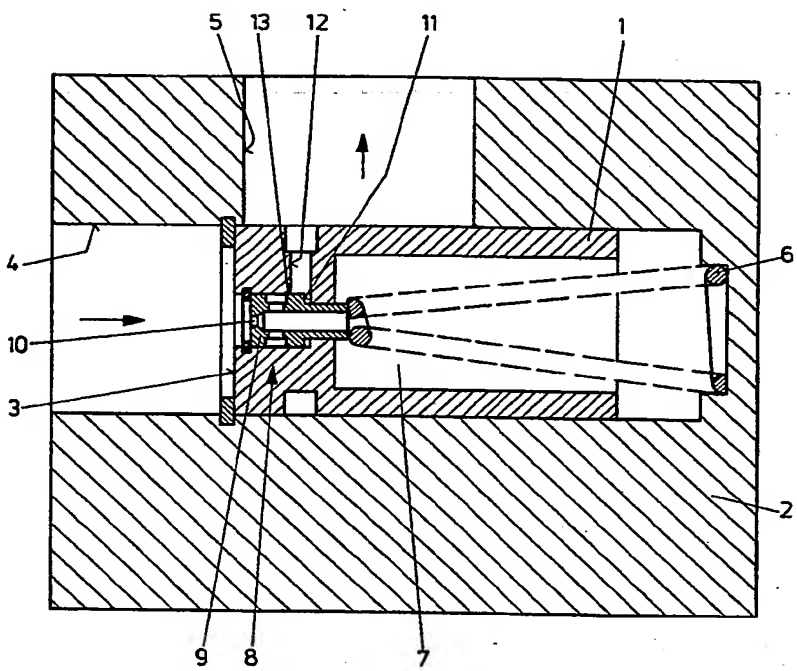
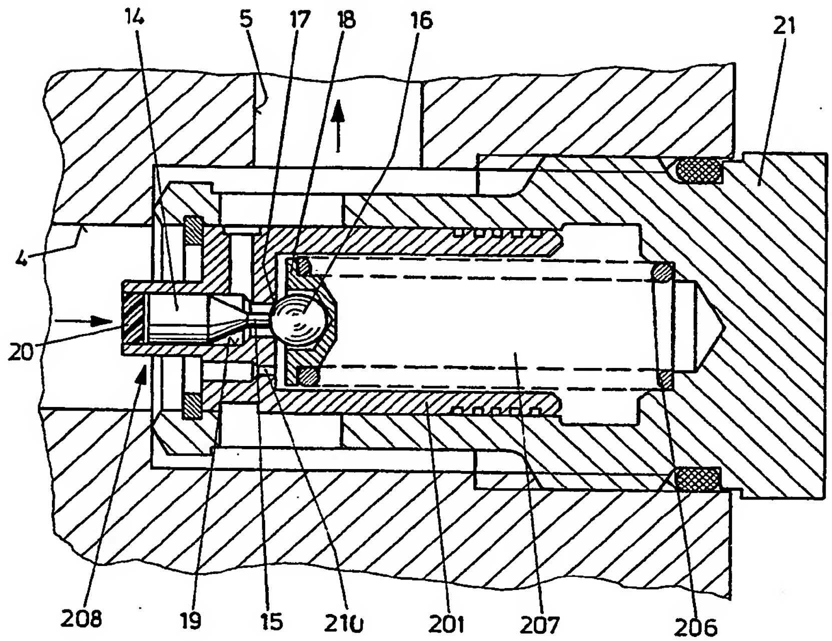


FIG.2



1466022 COMPLETE SPECIFICATION

10 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG.3

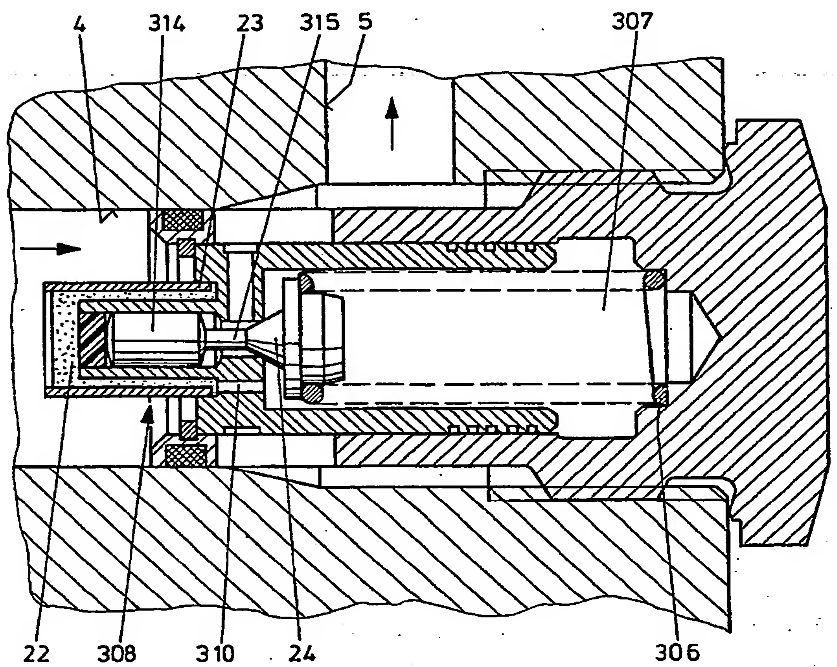


FIG. 4

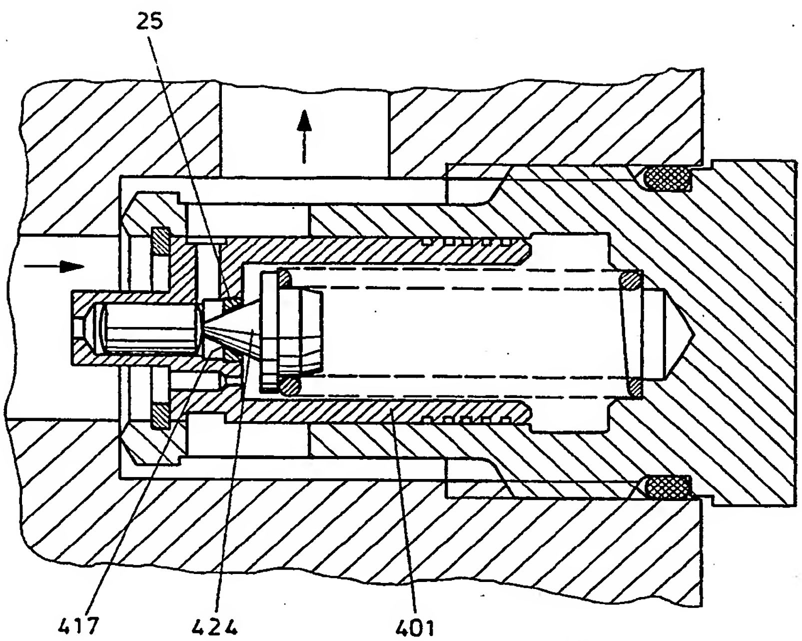


FIG. 5

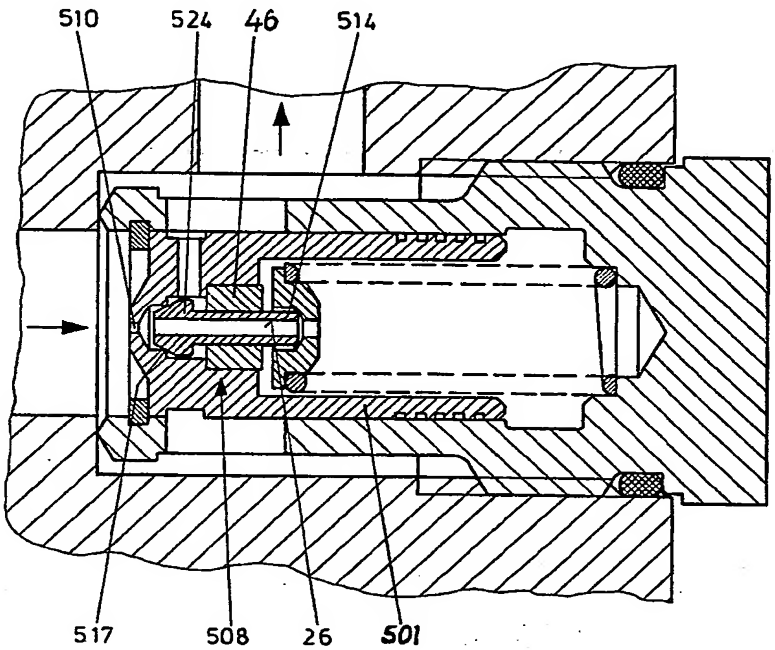
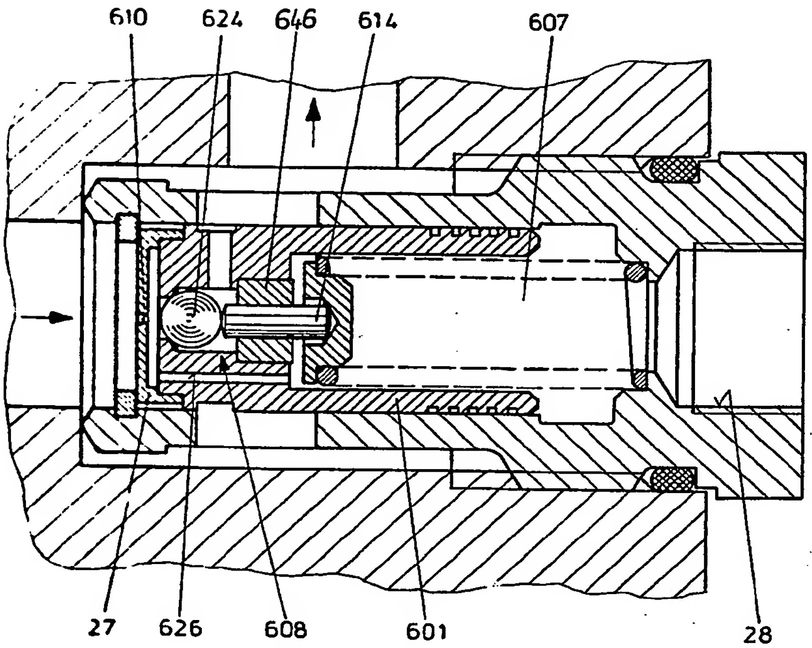


FIG.6



1466022 COMPLETE SPECIFICATION

10 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 7

FIG.7

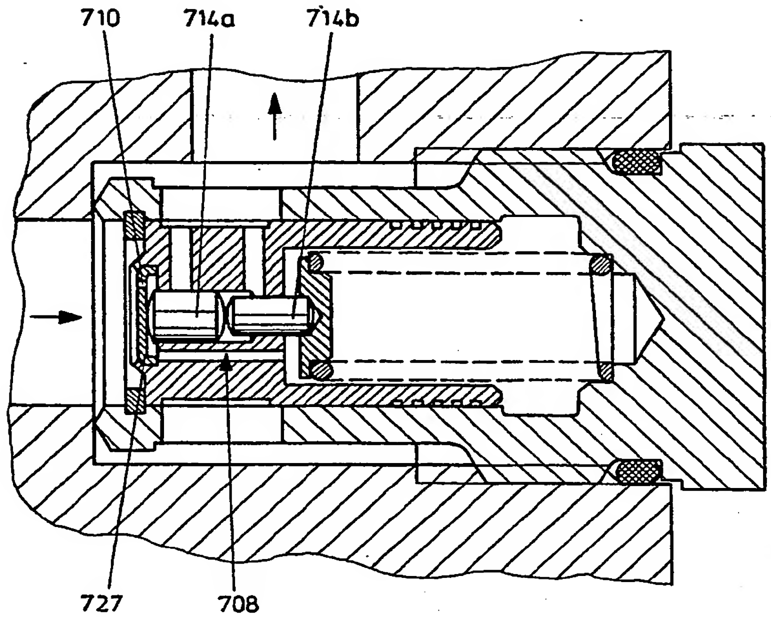


FIG. 8

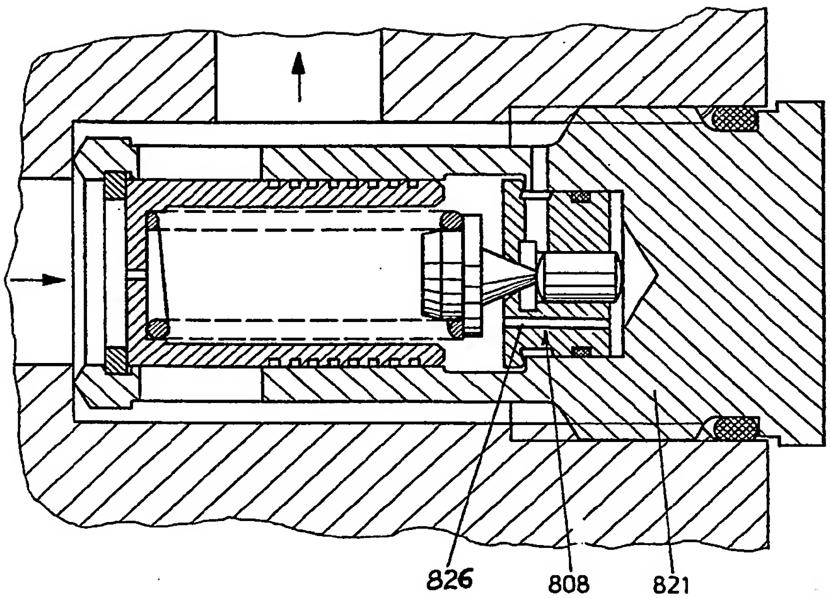


FIG. 9

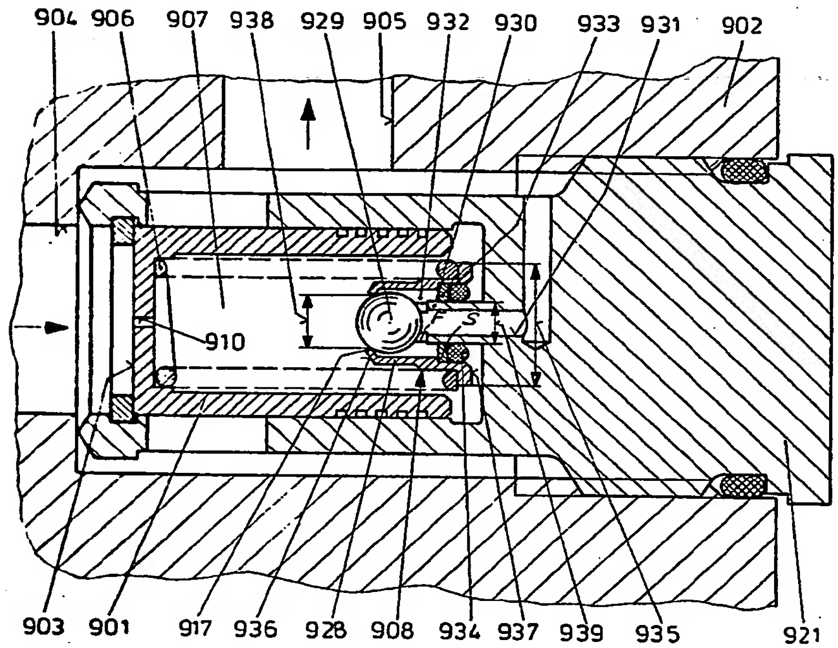
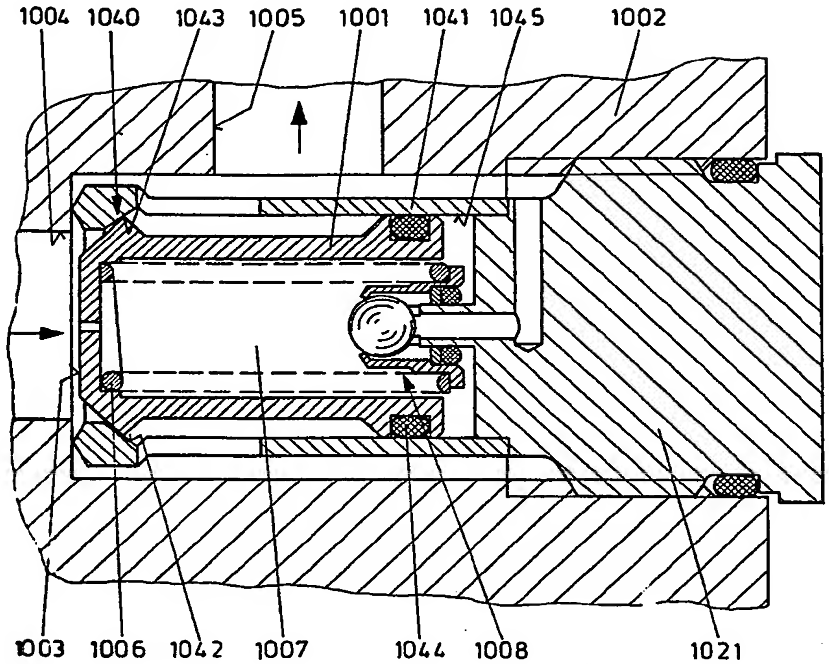

904
906
907
938
929
905
932
930
933
931
902
910
F
S
903
901
917
936
928
908
934
937
939
935
921

FIG. 10


1004
1040
1043
1005
1001
1041
1045
1002
1003
1006
1042
1007
1044
1008
1021

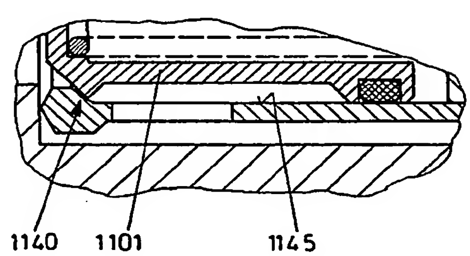

1140
1101
1145

FIG.11